The Solar Advocates Comments
Net Metering Workshop
Docket No. E-00000A-99-0431
October 20, 2006

Following the workshop on net metering held in Phoenix on September 7, 2006, American Solar Electric Inc., the Greater Tucson Coalition for Solar Energy, the Annan Group, Code Electric, Sun Edison and the Vote Solar Initiative respectively submits these comments in response to staff questions.

Net metering is a critical part of the regulatory infrastructure in enabling renewable, distributed generation. In the case of solar photovoltaics, net metering serves two complementary purposes: it makes solar systems effectively cheaper for system owners, and it helps increase solar's peak shaving impact and transmission and distribution effects (to the benefit of all ratepayers).

Current standards are insufficient, and unless addressed, will be a mission-fatal roadblock for the development of renewable resources in Arizona, and for meeting the future requirements of the proposed Renewable Energy Standard and Tariff. Currently, the major Arizona utilities have voluntarily established the following:

- Tucson Electric (TEP) limits net metering to systems less than 10 kW, with a system-wide cumulative cap of 200 kW. TEP will allow systems up to 50 kW to interconnect (but not net meter excess production) with an interconnection agreement. Systems larger than 50 kW are dealt with on a case-by-case basis.

- Arizona Public Service (APS) does not provide net metering. Instead, it offers 'net billing', wherein qualifying systems are outfitted with bi-directional meters, and excess production metered, then purchased by APS at wholesale rates.

Net metering is a critical enabling policy for renewable resources that are intermittent and non-dispatchable. The Governor, the state legislature, and the Arizona Corporation Commission are all on record as seeking to increase the amount of renewable energy in the state. Indeed, the ACC is currently near the end of rulemaking that would require a radical increase the amount of distributed generation in the state. It makes no sense to propose such a requirement without preparing the conditions for success. Net metering is one such condition.

We respectfully recommend that the Commission conduct rulemaking to establish a net metering standard in Arizona that corresponds to the state's renewable energy and distributed generation goals. In correspondence with precedence in other leading states, we recommend that any cap on eligible system size be no less than 2 MW, and any cap on total aggregate generation be no less than the Renewable Energy Standard and Tariff requirement.

1. How would net metering support the three purposes of PURPA?

A. Conservation of energy supplied by electric utilities

Net metering facilitates distributed on-site customer generation. Such generation reduces transmission and distribution losses, conserving energy supplied by utilities. Additionally, by facilitating diverse energy use and location of generation, customer generation can reduce fuel and disruption risks, effectively lowering the cost of energy supplied by utilities and conserving rate payer assets.

B. Optimal efficiency of electric utility facilities and resources
By enabling distributed generation, net metering can reduce utility peak load, more cost-effectively and efficiently than peaker plant development and other strategies. Net metering facilitates the proliferation of smaller, scalable generation to meet the need as it is in the near term, instead of building for an uncertain far-off load future, and associated financial/ operational costs and risks. Further, by facilitating customer sited generation, the value and effectiveness of distribution and transmission assets can be extended, providing value to all customers. and makes the grid more robust.

C. Equitable rates for electric consumers
Net metering effectively reduces peak load, reducing the amount of the most expensive electricity that utilities must generate or purchase for their customers. Net metering can also relieve strain on distribution and transmission assets. Reducing peak load and delaying and/or eliminating the need for distribution and transmission investment saves money for all ratepayers.

We provide more detail below.

2. Participation in and eligibility for net metering

A. Cap on Total Installed Capacity?
The Arizona Corporation Commission is currently developing a rulemaking (Docket No. RE-00000C-05-0030) that would require a radical increase in the amount of distributed generation in the state. Net metering is a critical part of the regulatory infrastructure that will allow those resources to be brought on-line. It would be counterproductive and illogical to set a cap restricting net metering to a level short of that required by another rulemaking.

To provide context, New Jersey, Pennsylvania, and Colorado all have *no* restrictions on the total aggregate capacity of net metered systems in their state. California recently passed a law, SB 1, that quintupled the net metering cap from 0.5% to 2.5% of total system peak load in order in part to address their own rulemaking-derived solar deployment goals.

The Renewable Energy Standard and Tariff in its most current proposed form would require that utilities procure 15% of their portfolio from renewable resources by 2025, with 30% of that requirement coming from distributed generation. Depending on the rate of load growth, if the DG requirement was served by photovoltaics, this would require between 1,800 MW (based upon the 3% growth rate used by ACC staff) and 2,500 MW (based upon the 4.6% figure used by APS in their rate case filings) of distributed renewables.

While clearly not all of the DG resources required by the REST would come from photovoltaics, a significant majority would. Since the rule is designed to stimulate the renewable energy industry in the state—not set a limit on it—we recommend that the ACC establish a net metering aggregate capacity limit larger than what the REST requires.

B. Restriction on Size of System?
To begin, we note that safety considerations will be dealt with through the interconnection process. Our suggestions in this regard are contained in the draft Arizona Interconnection Standard, currently before Commission staff.

The simple fact of the matter is that any state that is serious about distributed generation has a high net metering cap. California, with by far the most interconnected distributed generation in the country, has a cap of 1 MW. New Jersey, Colorado, and Pennsylvania--all states with ambitious solar programs--all provide net metering for systems up to 2 MW.

One reason why raising the system size is important is because larger systems are cheaper to install, due to greater standardization of components, a generally easier physical environment in which to work (e.g. commercial flat roofs,) and economies of scale in both materials (e.g. large panel buys) and overhead (labor, administration, etc.). An analysis of California data (as of November 2005) shows the following approximate costs for installed systems rebated in that state:

Size (kW)	Median Installed Cost	% reduction
50-100kW	$8.80	-2%
100-250 kW	$8.26	-6%
250-500 kW	$8.00	-3%
500-1000kW	$7.31	-9%

If the aim is to reduce ratepayer impacts of net metering, the ACC should not arbitrarily limit the state to only the more expensive smaller systems.

Given that the FERC standard interconnection rules uses 2 MW as the breakpoint for simplified interconnection, and the precedents set in other states serious about renewable distributed generation, we recommend that the ACC follow suit by providing net metering to qualifying facilities up to 2 MW in size.

C. Which customer sectors should be allowed to participate?
Net metering should be offered to all customer classes. The costs and benefits of net metering are influenced by the total amount of participation; the impacts do not change depending on the types of customers that participate.

In addition, the Energy Policy Act of 2005 requires utilities to offer net metering to all customers. Section 1251 of this bill amends the Public Utility Regulatory Policies Act of 1978 to include the following requirement: "Each electric utility shall make available upon request net metering service to any electric consumer that the electric utility serves."

D. What type of generation resources should be allowed to participate?
At a minimum, net metering should be offered to all generating resources allowed under the Renewable Energy Standard and Tariff. Net metering is a critical enabling policy for renewable resources that are intermittent and non-dispatchable. The Governor, the state legislature, and the Arizona Corporation Commission are all on record as seeking to increase the amount of renewable energy in the state. It is

prudent policymaking to develop these parallel rules in a supportive, synergistic, and complementary way.

In addition, some states allow co-gen and other highly-efficient non-renewable distributed generation technologies to net meter. Staff should examine the extent to which non-renewable distributed generation can reduce peak loads and provide other grid benefits in Arizona and make decisions accordingly.

3. What types of meters should be used for net metering?

Needlessly complicating the metering arrangements for small net metered systems can add substantial and unnecessary costs.

Consider that the simplest means of implementing true retail rate net metering is through a single register electromechanical meter, using commodity technology that has existed for decades, and read and reported according to existing utility practice with. Such devices are capable of true retail rate net metering with no--or only very minor--modifications to either the device or to utility procedure.

In the September Phoenix workshop initiating this proceeding, several utilities indicated that their current (or future) meters may have lost this capability. Since net metering capability is a requirement for a substantial fraction of the metering market according to state regulation, if this is in fact the case, we would request that the utilities provide information as to the type and model of meters which share this defect, the availability (from the same manufacturer or others) of compatible meters which remedy it, and the costs of both.

Going forward, we respectfully submit that in a market where viable alternatives are inexpensively available, it would be apparently imprudent to purchase metering equipment which was known to the utilities to be incapable of compliance with pending net metering requirements.

In the above context, we propose that a simple single bidirectional meter is adequate and appropriate for metering purposes all installations of 10 kilowatts or below (including likely all residential customers.) (It may well be the case that the proposed REST will bring in additional production metering requirements for small customer–generators.)

For larger systems (above 10 kW,) a secondary meter at customer expense represents an acceptable cost in the context of larger total installed costs; however, in no case should the additional information made available to the utility under this arrangement be used to differentiate onsite load displacement from energy efficiency – a distinction that would be otherwise impossible.

4. How should net excess generation be treated?

To begin, we note that with classic net metering, there is no buy/sell transaction up to net consumption. The Federal Energy Regulatory Commission has very clearly ruled to this effect. From FERC's decision in MidAmerican v. Iowa Utility Board: "In the case before us we find likewise that no sale occurs when an individual homeowner or farmer (or similar entity such as a business) installs generation and accounts for its dealings with the utility through the practice of netting."[1]

Generation in excess of consumption in a billing cycle is another matter. We recommend that monthly net excess generation be carried forward at the full retail rate as a credit to the next billing period; accounts should be trued-up annually with the annual surplus compensated at the avoided cost of generation.

To establish the correct context, we begin by noting that in the case of solar photovoltaics, the economics are such that it makes little sense for solar system owners to size their systems to be net energy generators. Experience in other states demonstrates that in fact, very few net metering customers are net generators on an annual basis. Pacific Gas and Electric has the most net-metered customers of any utility in the country. Of the 15,493 annual account true-ups that PG&E has conducted to date, only 1,113 showed net annual generation. However, the ability to receive appropriate credit for *monthly* net generation is key to optimizing systems for residential use (and not incidentally, Arizona system benefits).

Given the facts that, 1) Arizona's peak load is in the summer; 2) utility costs are to a great extent driven by the peak; and 3) Arizona's solar resource is best in summer; it makes sense to establish policies that will maximize the ability of distributed generation to reduce peak load and thereby save money for all ratepayers. For this reason, we recommend that Arizona establish a policy that encourages system owners to size their system optimally to meet their total annual load.

The alternative is a policy that requires a monthly settling of accounts with net excess paid at the avoided cost of generation. This is not only less advantageous, but adds substantial administrative costs by greatly increasing the number of true-ups that must be completed and accounted for.

Given the seasonal differentiation in load needs, this would incentivize system owners to size their system to meet the load of their least-consuming month. As a result, the systems would be undersized to meet customer demand during the high load months, and would contribute less of a peak shaving effect.

It makes sense to establish a policy that will maximize the beneficial impacts of net metered solar systems. Given the seasonal differentiation of load, this is best achieved through annual account reconciliation - the practice employed by the leading distributed generation states of California, New Jersey, and Colorado, among others.

5. Who should pay the costs of net metering?

An honest examination of cost implications will weigh both sides of the ledger - costs as well as benefits. The cost impacts of net metering on the utility and other ratepayers are exactly the same as for a customer that reduces load through conservation or energy efficiency measures. These types of investments are universally considered as beneficial for all parties involved. It is our strong recommendation that this question be re-framed without its current implicit bias.

---

[1] See page 6 of the decision, found at: http://www.irecusa.org/articles/static/1/binaries/mid-american-decision.pdf

The body of ratepayers will not only pay the costs of net metering, but reap the benefits--which all available research suggests far outweigh those costs.

Further, the simple fact of the matter is that about 40 states have adopted true retail net metering, and in no state is the utility allowed to recover alleged "costs" from a renewable energy surcharge designed exclusively to deploy additional renewable generation.

6. Should rate structures be changed to accommodate net metering? If so, how?

Net metering should be offered to all customers as per their current tariff, without imposing additional charges or fees. For time of use tariffs, the most administratively easy way to deal with them is California's model, where the customer-generator is credited with value of kWh fed into the grid under their applicable rateplan, then draws upon that value whenever taking power from the grid.

7. What are the costs and benefits of net metering?

True retail net metering is quite simply a threshold issue for the development of distributed generation. Without net metering, there will not be significant development of distributed generation, particularly renewables. Accordingly, the benefits of this policy can be examined from the perspective of the benefits of renewable distributed generation in general.

There are three main arguments for net metering. First, it greatly simplifies the operation of an interconnected solar system and lowers the cost of the system. Secondly, an examination of cost-shift concerns does not justify negative treatment. And finally, net metering enhances the viability of distributed generation (DG) solar, and DG solar provides numerous benefits to the grid and other ratepayers (e.g. reducing peak demand and peak energy purchases, diversifying fuel sources, reducing fuel consumption, improving grid efficiency, avoiding transmission and distribution upgrades, and reducing environmental degradation), savings which may more than make up for any lost revenue.

A. Net metering simplifies installation and makes solar cheaper. Because solar produces electricity during the day, system owners may not be using the power when it is generated, and net metering allows them to receive the full value of the electricity without installing expensive battery storage systems. In most cases, customers can use their existing meters, which further reduces costs by avoiding the need for a second meter installation or a meter replacement. A recent economic analysis estimated that net metering effectively makes solar 25% cheaper for system owners[2].

B. Cost-shift issues: A common argument against net metering is that certain costs are shifted to non-net metered ratepayers. In the most simplistic consideration of the issue, because net metered customers reduce their consumption, they contribute less to the fixed costs of operating the grid. These costs, it is sometimes argued, are transferred to non-net metered ratepayers, who effectively subsidize net metered

---

[2] Wenger, Howard: *Net Metering Economics and Electric Rate Impacts*. Presented at the American Solar Energy Society's Solar '98 Conference, Albuquerque, NM, June 1998, pg. 4.

systems' use of the grid. A closer examination of the issue reveals that the cost-shift argument does not justify negative treatment of net metering.

1. *Net Metering impacts are equivalent to other forms of energy reduction.* A net metered solar system does reduce consumption—but the same is true of a solar energy customer who installs batteries to store excess solar production for later usage, or a utility customer who reduces load through conservation or installing energy efficiency technologies. In neither of the latter two scenarios would utility customers be expected to make a special payment to address their reduced contribution to fixed costs. As the impacts on the utility and other ratepayers are the same, net metered solar system owners should not be treated differently. In fact, the net metered customer is providing high value, peak kWh onto the grid at the low voltage distribution level, thereby reducing pressure on the overall transmission and distribution system to the benefit of all.

2. *Grid usage is minimal.* Power supplied to the grid by the net metered system is consumed by the nearest neighboring load. In some cases, this means the power will barely enter the grid, traveling on the low side of a customer transformer from one neighbor to another. This minimal grid usage does not justify a buy/sell dual metering arrangement, wherein the utility would be charging the recipient customer for the full cost of a transmission and distribution system only a miniscule fraction of which had been used in the transaction.

3. *The alternative, dual metering (also known as net billing), incurs costs.* Measures to avoid the loss of T&D revenue incurs additional administrative costs—new costs that are roughly comparable to the revenue loss avoided. Systems on a net metering arrangement can usually utilize currently installed meters, and there are no additional meter reading or billing costs incurred. With dual billing (net billing), new meters that measure bi-directional flow must be installed, and utility meter reading and billing practices must be changed to collect information on electricity fed back into the grid, calculate its value, and cut checks to system owners. These hardware and administrative costs can be avoided with net metering.

C. Value of Distributed Generation Solar to the Grid

Every solar panel installed provides economic benefits for all utility customers by reducing the overall cost of producing and delivering electricity. As photovoltaics produce the most electricity during peak demand periods, the benefits of net metered solar systems are magnified.

Studies in other states have established high values for distributed generation solar systems. A study of California's system found the value of on-peak solar to be between $0.231-$0.352/kWh[3]. A study in the New York City area found that the avoided generation capacity benefits alone of PV was worth 9.1 cents/kWh, and when avoided transmission capacity and line losses were accounted for, the benefits rose to 16.6 cents/kWh[4]. These values are significantly greater than retail power

---

[3] Smeloff, Edward: *Quantifying the Benefits of Solar Power for California*. January 2005. www.votesolar.org

[4] Perez, P., T. Hoff, L. Burtis, S. Swanson, C. Herig: *Quantifying Residential PV Economics—Payback vs. Cash Flow, Determination of Fair Energy Value*. Proceedings of ASES 2003, funded in part by NREL.

costs (meaning the solar energy system owner may be cross subsidizing other utility customers).

Other benefits of distributed generation solar in Arizona include:

- Peak Demand Reductions—Properly oriented solar power systems can produce electricity that closely matches the use of air conditioning loads, thus reducing peak demand. Credit should be set based upon the effective load carrying capacity (ELCC). While solar generation is reduced on cloudy days, the PV availability factor on system peak days has proven highly reliable[5,6]. See Richard Perez's recent Arizona specific study in the Appendix for more details.

- Avoided Generation Fuel Cost—Each kilowatt generated by solar power systems displaces other utility generation on peak when fuel costs are highest, thereby reducing costs for all utility customers.[7,8,9]

- Avoided Transmission and Distribution Upgrade Costs—Because solar power is located where it is consumed, it can help avoid or defer the need for new power lines. Installations in load pockets maximize this value.

- Avoided Transmission and Distribution Losses—Since DG solar power is located at the point of use, line losses, typically 7-10%, are avoided. (Note that line losses are significantly higher during peak demand periods when solar is at its maximum production.)

- Energy Security—Distributed generation can protect against catastrophic failure.[10,11,12]

- Fuel Diversification—Solar, with no fuel costs, provides a hedge value against volatile fossil fuel-driven electricity costs.[13]

---

[5] Perez, P., C. Herig, S. Letendre: PV and Grid Reliability: *Availability of PV Power During Capacity Shortfalls*. Funded by NREL and NYSERDA.
[6] Herig, Christy: *Using Photovoltaics to Preserve California's Electricity Capacity Reserves*. NREL.
[7] Duke, Richard, Robert Williams and Adam Payne, 2004, "Accelerating Residential PV Expansion: Demand Analysis for Competitive Electricity Markets," *Energy Policy*.
http://www.nrel.gov/ncpv/thin_film/pdfs/energy_policy_pv_expansion_residential_demand_issues.pdf
[8] Orans, R. et al: Methodology and Forecast of Long Term Avoided Costs for the Evaluation of California Energy Efficiency Programs," Energy and Environmental Economics, Inc. and Rocky Mountain Institute, report prepared for the California Public Utilities Commission, October 25, 2004.
http://www.ethree.com/cpuc_avoidedcosts.html
[9] Wiser, Ryan, M. Bolinger, and M. St. Clair: *Easing the Natural Gas Crisis: Reducing Natural Gas Prices through Increased Deployment of Renewable Energy and Energy Efficiency*. LBNL, prepared for DOE. January 2005. http://eetd.lbl.gov/ea/ems/reports/56756.pdf
[10] Perez, Richard et al, "Availability of Dispersed Photovoltaic Resource During the August 14th 2003 Northeast Power Outage", ASES proceedings, 2004. Available at:
http://www.asrc.cestm.albany.edu/perez/2003-2004/outage.pdf
[11] Letendre, Steven, and Richard Perez, "Understanding the Benefits of Dispersed Grid-Connected Photovoltaics: From Avoiding the Next Major Outage to Taming Wholesale Power Markets", June 2006. Available at: http://www.asrc.cestm.albany.edu/perez/2006/letendre-perez-Elejrnl-06-06.pdf
[12] Reka Albert, Istvan Albert, Gary Nakarado, "Structural vulnerability of the North American power grid" preprint, http://xxx.lanl.gov/abs/cond-mat/0401084 (2004)
[13] Bolinger, Mark, Ryan Wiser and William Golove: *Accounting for Fuel Price Risk When Comparing Renewable to Gas-Fired Generation: The Role of Forward Natural Gas Prices*. January 2004.
http://eetd.lbl.gov/EA/EMP/reports/56756.pdf

- Avoided Water Use Cost—Competing generation sources use tremendous amounts of water, an increasingly scarce and valuable resource in Arizona.[14]

- Compliance Benefits—The readily quantifiable benefits include reductions in regulated emissions (NOx and SOx). Reasonable estimates can also be made for the hedging value of reducing greenhouse gases, such as CO2 and methane, which are not currently controlled but will likely be in the future. Pricewaterhouse Coopers recently issued a report which estimated the cost of controlling carbon globally at $1 trillion—which the study concluded paled in comparison to the costs of not controlling carbon.[15]

- Environmental Benefits--More difficult to quantify are the very real negative impacts that emissions from fossil fuel power generation has on public health and the environment. In this country, emissions from fossil fuel electricity generation are the single largest contributor of global warming gases. Recent studies have estimated the partial future costs of climate change to be staggering. The European Commission puts it at $74 trillion, the German Institute for Economic Research at $20 trillion annually by 2100, and a study by Tufts University concludes that both these figures are gravely undervalued.[16] Emissions from fossil fuel energy production are also toxic to human health, estimated to shorten the lives of 30,000 Americans every year.[17] Though difficult to quantify precisely, avoiding these consequences of fossil fuel energy production has immense value. Much of Arizona's current generation is derived from fossil fuels, and the owners of this generation shift 100% of these costs off the balance books and onto others. Net metered renewable systems do not incur these costs.

- Economic Benefits from Job Creation—Solar creates more jobs per megawatt than any other energy source. On an energy capacity basis, solar energy creates 35.5 person-years per MW (at least 30% of those local), and on an operating basis, calculated over 10 years, solar PV creates 40% more jobs per dollar than coal.[18]

In sum, net metering simply makes the relationship between the grid's shortcomings and a solar system's attributes more rational and efficient.

8. What are other issues related to net metering?

Several parties at the initial workshop expressed a concern that the intermittency of the solar resource would mean that it had no capacity value – that in effect all solar resources would need to be backed up for the totality of their capacity by conventional generation, and that this in part justified paying less than full retail value for the energy they generated.

---

[14] *The Last Straw: Water Use by Power Plants in the Arid West.* Hewlett Foundation Energy Series, April 2003, http://www.catf.us/publications/reports/The_Last_Straw.pdf
[15] Hawksworth, John "The World in 2050; Impact of global growth on carbon emissions and climate change policy", Pricewatershouse Coopers, September 2006. www.pwc.com/carbon
[16] Ackerman, Frank and Elizabeth Stanton, "Climate Change—the Cost of Inaction" Global Development and Environment Institute, Tufts University, October 11, 2006.
[17] Schneider, Conrad, *Death, Disease, and Dirty Power; Mortality and Health Damage Due to Air Pollution from Power Plants*, Clean Air Task Force with Abt Associates, October 2000.
[18] Renewable Energy Policy Project, *The Work That Goes Into Renewable Energy,* November 2001.

This is incorrect. The rising and setting of the sun, and the progress of any potentially obscuring weather, are several times more predictable on any timescale than the other contingencies for which generation capacity is designated. Utilities are generally among the economy's savviest consumers of weather forecast information, and this should provide a much higher degree of capacity certainty than should the unpredictable mechanical failure of a generator or the impingement of a tree limb on a transmission line.

In order to empirically demonstrate this effect for Arizona specifically, the solar industry commissioned a study by Dr. Richard Perez, Senior Research Associate at the SUNY-Albany Atmospheric Sciences Research Center. The study – *Effective Capacity of Photovoltaic Power Generation in Arizona* (attached as Appendix 2) uses an analysis of modeled photovoltaic generation from satellite data, matched with load data for the same time period for the Salt River Project and Arizona Public Service, to demonstrate PV ELCCs of 49% of rated capacity at minimum, rising as high as 64% of capacity at low penetration levels in APS territory.

The study further demonstrates good correlation between Arizona peak loads and solar generation (as many of these loads are themselves solar driven through air conditioning demand.)

The necessary conclusion is that any calculation of the costs of net metering must subtract at least 50% of the capacity value that would otherwise be delivered free to the utilities absent such calculation. The study is attached.

Respectfully submitted October 20, 2006

By:______________________________

Sean Seitz, American Solar Electric Inc., on behalf of the Greater Tucson Coalition for Solar Energy, the Annan Group, Code Electric, Sun Edison and the Vote Solar Initiative

APPENDIX 1.

Small is Profitable: The Hidden Economic Benefits of Making Electrical Resources Right Sized[19] compiles the data, field research and framework for DG value and concludes that the aggregate value from a societal perspective can be as much as an order of magnitude greater than the wholesale value of power for renewable energy and three to five times the wholesale value for non-renewable distributed generation.

It can be downloaded for a nominal fee from www.smallisprofitable.org

Small is Profitable, in addition to compiling the research, also offers 207 benefits of distributed generation, the majority cited out to specific professional literature in the power engineering, systems analysis, and utility operations fields.

Following is the list of those benefits, all of which contribute to reducing the risk of investing, building, maintaining and effectively utilizing electrical assets. In these times of fuel cost volatility, ***reducing risk by design*** in all parts of the electrical power generation and delivery business, can only help protect us, and at least, cushion us against the pain of unforeseeable events.

207 Benefits of Distributed Resources

1 Distributed resources' generally shorter construction period leaves less time for reality to diverge from expectations, thus reducing the probability and hence the financial risk of under- or overbuilding.

2 Distributed resources' smaller unit size also reduces the consequences of such divergence and hence reduces its financial risk.

3 The frequent correlation between distributed resources' shorter lead time and smaller unit size can create a multiplicative, not merely an additive, risk reduction.

4 Shorter lead time further reduces forecasting errors and associated financial risks by reducing errors' amplification with the passage of time.

5 Even if short-lead-time units have lower thermal efficiency, their lower capital and interest costs can often offset the excess carrying charges on idle centralized capacity whose better thermal efficiency is more than offset by high capital cost.

6 Smaller, faster modules can be built on a "pay-as-you-go" basis with less financial strain, reducing the builder's financial risk and hence cost of capital.

7 Centralized capacity additions overshoot demand (absent gross under forecasting or exactly predictable step-function increments of demand) because their inherent "lumpiness" leaves substantial increments of capacity idle until demand can "grow into it." In contrast, smaller units can more exactly match gradual changes in demand without building unnecessary slack capacity ("build-as-you-need"), so their capacity additions are employed incrementally and immediately.

8 Smaller, more modular capacity not only ties up less idle capital (#7), but also does so for a shorter time (because the demand can "grow into" the added capacity

---

[19] A. Lovins, E.K. Datta, T. Feiler, K.R. Rabago, J.N. Swisher, A. Lehmann and K. Wicker. *Small is Profitable, The Hidden Economic Benefits of Making Electrical Resources the Right Size*. Rocky Mountain Institute, 2002.

sooner), thus reducing the cost of capital per unit of revenue.

9 If distributed resources are becoming cheaper with time, as most are, their small units and short lead times permit those cost reductions to be almost fully captured. This is the inverse of #8: revenue increases there, and cost reductions here, are captured incrementally and immediately by following the demand or cost curves nearly exactly.

10 Using short-lead-time plants reduces the risk of a "death spiral" of rising tariffs and stagnating demand.

11 Shorter lead time and smaller unit size both reduce the accumulation of interest during construction—an important benefit in both accounting and cashflow terms.

12 Where the multiplicative effect of faster-and-smaller units reduces financial risk (#3) and hence the cost of project capital, the correlated effects—of that cheaper capital, less of it (#11), and needing it over a shorter construction period (#11)—can be triply multiplicative. This can in turn improve the enterprise's financial performance, gaining it access to still cheaper capital. This is the opposite of the effect often observed with large-scale, long-lead-time projects, whose enhanced financial risks not only raise the cost of project capital but may cause general deterioration of the developer's financial indicators, raising its cost of capital and making it even less competitive.

13 For utilities that use such accrual accounting mechanisms as AFUDC (Allowance for Funds Used During Construction), shorter lead time's reduced absolute and fractional interest burden can improve the quality of earnings, hence investors' perceptions and willingness to invest.

14 Distributed resources' modularity increases the developer's financial freedom by tying up only enough working capital to complete one segment at a time.

15 Shorter lead time and smaller unit size both decrease construction's burden on the developer's cashflow, improving financial indicators and hence reducing the cost of capital.

16 Shorter-lead-time plants can also improve cashflow by starting to earn revenue sooner—through operational revenue-earning or regulatory rate-basing as soon as each module is built—rather than waiting for the entire total capacity to be completed.

17 The high velocity of capital (#16) may permit self-financing of subsequent units from early operating revenues.

18 Where external finance is required, early operation of an initial unit gives investors an early demonstration of the developer's capability, reducing the perceived risk of subsequent units and hence the cost of capital to build them.

19 Short lead time allows companies a longer "breathing spell" after the startup of each generating unit, so that they can better recover from the financial strain of construction.

20 Shorter lead time and smaller unit size may decrease the incentive, and the bargaining power, of some workers or unions whose critical skills may otherwise give them the leverage to demand extremely high wages or to stretch out construction still further on large, lumpy, long-lead-time projects that can yield no revenue until completed.

21 Smaller plants' lower local impacts may qualify them for regulatory exemptions or streamlined approvals processes, further reducing construction time and hence financing costs.

22 Where smaller plants' lower local impacts qualify them for regulatory exemptions or streamlined approvals processes, the risk of project failure and lost investment due to regulatory rejection or onerous condition decreases, so investors may demand a smaller risk premium.

23 Smaller plants have less obtrusive siting impacts, avoiding the risk of a vicious circle of public response that makes siting ever more difficult.

24 Small units with short lead times reduce the risk of buying a technology that is or becomes obsolete even before it's installed, or soon thereafter.

25 Smaller units with short development and production times and quick installation can better exploit rapid learning: many generations of product development can be compressed into the time it would take simply to build a single giant unit, let alone operate it and gain experience with it.

26 Lessons learned during that rapid evolution can be applied incrementally and immediately in current production, not filed away for the next huge plant a decade or two later.

27 Distributed resources move labor from field worksites, where productivity gains are sparse, to the factory, where they're huge.

28 Distributed resources' construction tends to be far simpler, not requiring an expensively scarce level of construction management talent.

29 Faster construction means less workforce turnover, less retraining, and more craft and management continuity than would be possible on a decade-long project.

30 Distributed resources exploit modern and agile manufacturing techniques, highly competitive innovation, standardized parts, and commonly available production equipment shared with many other industries. All of these tend to reduce costs and delays.

31 Shorter lead time reduces exposure to changes in regulatory rules during construction.

32 Technologies that can be built quickly before the rules change and are modular so they can "learn faster" and embody continuous improvement are less exposed to regulatory risks.

33 Distributed technologies that are inherently benign (renewables) are less likely to suffer from regulatory restrictions.

34 Distributed resources may be small enough per unit to be considered *de minimis* and avoid certain kinds of regulation.

35 Smaller, faster modules offer some risk-reducing degree of protection from interest-rate fluctuations, which could be considered a regulatory risk if attributed to the Federal Reserve or similar national monetary authorities.

36 The flexibility of distributed resources allows managers to adjust capital investments continuously and incrementally, more exactly tracking the unfolding future, with continuously available options for modification or exit to avoid trapped equity.

37 Small, short-lead-time resources incur less carrying-charge penalty if suspended to await better information, or even if abandoned.

38 Distributed resources typically offer greater flexibility in accelerating completion if this becomes a valuable outcome.

39 Distributed resources allow capacity expansion decisions to become more routine and hence lower in transaction costs and overheads.

40 Distributed generation allows more learning before deciding, and makes learning a continuous process as experience expands rather than episodic with each lumpy, all-or-nothing decision.

41 Smaller, shorter-lead-time, more modular units tend to offer cheaper and more flexible options to planners seeking to minimize regret, because such resources can better adapt to and more cheaply guard against uncertainty about how the future will unfold.

42 Modular plants have off-ramps so that stopping the project is not a total loss: value can still be recovered from whatever modules were completed before the stop.

43 Distributed resources' physical portability will typically achieve a higher expected value than an otherwise comparable non-portable resource, because if circumstances change, a portable resource can be physically redeployed to a more advantageous location.

44 Portability also merits a more favorable discount rate because it is less likely that the anticipated value will not be realized—even though it may be realized in a different location than originally expected.

45 A service provider or third-party contractor whose market reflects a diverse range of temporary or uncertain-duration service needs can maintain a "lending library" of portable distributed resources that can achieve high collective utilization, yet at each deployment avoid inflexible fixed investments that lack assurance of long-term revenue.

46 Modular, standardized, distributed, portable units can more readily be resold as commodities in a secondary market, so they have a higher residual or salvage value than corresponding monolithic, specialized, centralized, nonportable units that have mainly a demolition cost at the end of their useful lives.

47 The value of the resale option for distributed resources is further enhanced by their divisibility into modules, of which as many as desired may be resold and the rest retained to a degree closely matched to new needs.

48 Distributed resources typically do little or no damage to their sites, and hence minimize or avoid site remediation costs if redeployed, salvaged, or decommissioned.

49 Volatile fuel prices set by fluctuating market conditions represent a financial risk. Many distributed resources do not use fuels and thus avoid that costly risk.

50 Even distributed resources that do use fuels, but use them more efficiently or dilute their cost impact by a higher ratio of fixed to variable costs, can reduce the financial risk of volatile fuel prices.

51 Resources with a low ratio of variable to fixed costs, such as renewables and end-use efficiency, incur less cost volatility and hence merit more favorable discount rates.

52 Fewer staff may be needed to manage and maintain distributed generation plants: contrary to the widespread assumption of higher per-capita overheads, the small organizations required can actually be leaner than large ones.

53 Meter-reading and other operational overheads may be quite different for renewable and distributed resources than for classical power plants.

54 Distributed resources tend to have lower administrative overheads than centralized ones because they do not require the same large organizations with broad capabilities nor, perhaps, more complex legally mandated administrative and reporting requirements.

55 Compared with central power stations, mass-produced modular resources should have lower maintenance equipment and training costs, lower carrying charges on spare-parts inventories, and much lower unit costs for spare parts made in higher production runs.

56 Unlike different fossil fuels, whose prices are highly correlated with each other, non-fueled resources (efficiency and renewables) have constant, uncorrelated prices that reduce the financial risk of an energy supply portfolio.

57 Efficiency and cogeneration can provide insurance against uncertainties in load growth because their output increases with electricity demand, providing extra capacity in exactly the conditions in which it is most valuable, both to the customer and to the electric service provider.

58 Distributed resources are typically sited at the downstream (customer) end of the traditional distribution system, where they can most directly improve the system's lowest load factors, worst losses, and highest marginal grid capital costs—thus creating the greatest value.

59 The more fine-grained the distributed resource—the closer it is in location and scale to customer load—the more exactly it can match the temporal and spatial pattern of the load, thus maximizing the avoidance of costs, losses, and idle capacity.

60 Distributed resources matched to customer loads can displace the least utilized grid assets.

61 Distributed resource matched to customer loads can displace the part of the grid that has the highest losses.

62 Distributed resources matched to customer loads can displace the part of the grid that typically has the biggest and costliest requirements for reactive power control.

63 Distributed resources matched to customer loads can displace the part of the grid that has the highest capital costs.

64 Many renewable resources closely fit traditional utility seasonal and daily loadshapes, maximizing their "capacity credit"—the extent to which each kW of renewable resource can reliably displace dispatchable generating resources and their associated grid capacity.

65 The same loadshape-matching enables certain renewable sources (such as photovoltaics in hot, sunny climates) to produce the most energy at the times when it is most valuable—an attribute that can be enhanced by design.

66 Reversible-fuel-cell storage of photovoltaic electricity can not only make the PVs a dispatchable electrical resource, but can also yield useful fuel-cell byproduct heat at night when it is most useful and when solar heat is least available.

67 Combinations of various renewable resources can complement each other under various weather conditions, increasing their collective reliability.

68 Distributed resources such as photovoltaics that are well matched to substation peak load can precool the transfomer—even if peak load lasts longer than peak PV output—thus boosting substation capacity, reducing losses, and extending equipment life.

69 In general, interruptions of renewable energy flows due to weather can be predicted earlier and with higher confidence than interruptions of fossil-fueled or nuclear energy flows due to malfunction or other mishap.

70 Such weather-related interruptions of renewable sources also generally last for a much shorter time than major failures of central thermal stations.

71 Some distributed resources are the most reliable known sources of electricity, and in general, their technical availability is improving more and faster than that of centralized resources. (End-use efficiency resources are by definition 100% available—effectively, even more.)

72 Certain distributed generators' high technical availability is an inherent per-unit attribute—not achieved through the extra system costs of reserve margin, interconnection, dispersion, and unit and technological diversity required for less reliable central units to achieve the equivalent supply reliability.

73 In general, given reasonably reliable units, a large number of small units will have greater collective reliability than a small number of large units, thus favoring distributed resources.

74 Modular distributed generators have not only a higher collective availability but also a narrower potential range of availability than large, non-modular units, so there is less uncertainty in relying on their availability for planning purposes.

75 Most distributed resources, especially renewables, tend not only to fail less than centralized plants, but also to be easier and faster to fix when they do fail.

76 Repairs of distributed resources tend to require less exotic skills, unique parts, special equipment, difficult access, and awkward delivery logistics than repairs of centralized resources.

77 Repairs of distributed resources do not require costly, hard-to-find large blocks of replacement power, nor require them for long periods.

78 When a failed individual module, tracker, inverter, or turbine is being fixed, all the rest in the array continue to operate.

79 Distributed generation resources are quick and safe to work with: no post-shutdown thermal cooling of a huge thermal mass, let alone radioactive decay, need be waited out before repairs can begin.

80 Many distributed resources operate at low or ambient temperatures, fundamentally increasing safety and simplicity of repair.

81 A small amount of energy storage, or simple changes in design, can disproportionately increase the capacity credit due to intermittent renewable resources.

82 Distributed resources have an exceptionally high grid reliability value if they can be sited at or near the customer's premises, thus risking less "electron haul length" where supply could be interrupted.

83 Distributed resources tend to avoid the high voltages and currents and the complex delivery systems that are conducive to grid failures.

84 Deliberate disruptions of supply can be made local, brief, and unlikely if electric systems are carefully designed to be more efficient, diverse, dispersed, and renewable.

85 By blunting the effect of deliberate disruptions, distributed resources reduce the motivation to cause such disruptions in the first place.

86 Distributed generation in a large, far-flung grid may change its fundamental transient-response dynamics from unstable to stable—especially as the distributed resources become smaller, more widespread, faster-responding, and more intelligently controlled.

87 Modular, short-lead-time technologies valuably temporize: they buy time, in a self-reinforcing fashion, to develop and deploy better technologies, learn more, avoid more decisions, and make better decisions. The faster the technological and institutional change, and the greater the turbulence, the more valuable this time-buying ability becomes. The more the bought time is used to do things that buy still more time, the greater the leverage in avoided regret.

88 Smaller units, which are often distributed, tend to have a lower forced outage rate and a higher equivalent availability factor than larger units, thus decreasing reserve margin and spinning reserve requirements.

89 Multiple small units are far less likely to fail simultaneously than a single large unit.

90 The consequences of failure are far smaller for a small than for a large unit.

91 Smaller generating units have fewer and generally briefer scheduled or forced maintenance intervals, further reducing reserve requirements.

92 Distributed generators tend to have less extreme technical conditions (temperature, pressure, chemistry, etc.) than giant plants, so they tend not to incur the inherent reliability problems of more exotic materials pushed closer to their limits—thus increasing availability.

93 Smaller units tend to require less stringent technical reliability performance (*e.g.*, failures per meter of boiler tubing per year) than very large units in order to achieve the same reliability (in this instance, because each small unit has fewer meters of boiler tubing)—thus again increasing unit availability and reducing reserves.

94 "Virtual spinning reserve" provided by distributed resources can replace traditional central-station spinning reserve at far lower cost.

95 Distributed substitutes for traditional spinning reserve capacity can reduce its operating hours—hence the mechanical wear, thermal stress, corrosion, and other gradual processes that shorten the life of expensive, slow-to-build, and hard-to-repair central generating equipment.

96 When distributed resources provide "virtual spinning reserve," they can reduce cycling, turn-on/shutdown, and low-load "idling" operation of central generating units, thereby increasing their lifetime.

97 Such life extension generally incurs a lower risk than supply expansion, and hence merits a more favorable risk-adjusted discount rate, further increasing its economic advantage.

98 Distributed resources can help reduce the reliability and capacity problems to which an aging or overstressed grid is liable.

99 Distributed resources offer greater business opportunities for profiting from hot spots and price spikes, because time and location-specific costs are typically more variable within the distribution system than in bulk generation.

100 Strategically, distributed resources make it possible to position and dispatch generating and demand-side resources optimally so as to maximize the entire range of distributed benefits.

101 Distributed resources (always on the demand side and often on the supply side) can largely or wholly avoid every category of grid costs on the margin by being already at or near the customer and hence requiring no further delivery.

102 Distributed resources have a shorter haul length from the more localized (less remote) source to the load, hence less electric resistance in the grid.

103 Distributed resources reduce required net inflow from the grid, reducing grid current and hence grid losses.

104 Distributed resources cause effective increases in conductor cross-section per unit of current (thereby decreasing resistance) if an unchanged conductor is carrying less current.

105 Distributed resources result in less conductor and transformer heating, hence less resistance.

106 Distributed resources' ability to decrease grid losses is increased because they are close to customers, maximizing the sequential compounding of the different losses that they avoid.

107 Distributed photovoltaics particularly reduce grid loss load because their output is greatest at peak hours (in a summer-peaking system), disproportionately reducing the heating of grid equipment.

108 Such on peak generation also reduces losses precisely when the reductions are most valuable.

109 Since grid losses avoided by distributed resources are worth the product of the number times the value of each avoided kWh of losses, their value can multiply rapidly when using area- and time-specific costs.

110 Distributed resources can reduce reactive power consumption by shortening the electron haul length through lines and by not going through as many transformers—both major sources of inductive reactance.

111 Distributed resources can reduce current flows through inductive grid elements by meeting nearby loads directly rather than by bringing current through lines and transformers.

112 Some end-use-efficiency resources can provide reactive power as a free byproduct of their more efficient design.

113 Distributed generators that feed the grid through appropriately designed DC-to-AC inverters can provide the desired real-time mixture of real and reactive power to maximize value.

114 Reduced reactive current improves distribution voltage stability, thus improving end-use device reliability and lifetime, and enhancing customer satisfaction, at lower cost than for voltage-regulating equipment and its operation.

115 Reduced reactive current reduces conductor and transformer heating, improving grid components' lifetime.

116 Reduced reactive current, by cooling grid components, also makes them less likely to fail, improving the quality of customer service.

117 Reduced reactive current, by cooling grid components, also reduces conductor and transformer resistivity, thereby reducing real-power losses, hence reducing heating, hence further improving component lifetime and reliability.

118 Reduced reactive current increases available grid and generating capacity, adding to the capacity displacement achieved by distributed resources' supply of real current.

119 Distributed resources, by reducing line current, can help avoid voltage drop and associated costs by reducing the need for installing equipment to provide equivalent voltage support or step-up.

120 Distributed resources that operate in the daytime, when sunlight heats conductors or transformers, help to avoid costly increases in circuit voltage, reconductoring (replacing a conductor with one of higher ampacity), adding extra circuits, or, if available, transferring load to other circuits with spare ampacity.

121 Substation-sited photovoltaics can shade transformers, thereby improving their efficiency, capacity, lifetime, and reliability.

122 Distributed resources most readily replace distribution transformers at the smaller transformer sizes that have higher unit costs.

123 Distributed resources defer or avoid adding grid capacity.

124 Distributed resources, by reducing the current on transmission and distribution lines, free up grid capacity to provide service to other customers.

125 Distributed resources help "decongest" the grid so that existing but encumbered capacity can be freed up for other economic transactions.

126 Distributed resources avoid the siting problems that can occur when building new transmission lines.

127 These siting problems tend to be correlated with the presence of people, but people tend to correlate with both loads and opportunities for distributed resources.

128 Distributed resources' unloading, hence cooling, of grid components can disproportionately increase their operating life because most of the life-shortening effects are caused by the highest temperatures, which occur only during a small number of hours.

129 More reliable operation of distribution equipment can also decrease periodic maintenance costs and outage costs.

130 Distributed resources' reactive current, by improving voltage stability, can reduce tapchanger operation on transformers, increasing their lifetime.

131 Since distributed resources are nearer to the load, they increase reliability by reducing the length the power must travel and the number of components it must traverse.

132 Carefully sited distributed resources can substantially increase the distribution system operator's flexibility in rerouting power to isolate and bypass distribution faults and to maintain service to more customers during repairs.

133 That increased delivery flexibility reduces both the number of interrupted customers and the duration of their outage.

134 Distributed generators can be designed to operate properly when islanded, giving local distribution systems and customers the ability to ride out major or widespread outages.

135 Distributed resources require less equipment and fewer procedures to repair and maintain the generators.

136 Stand-alone distributed resources not connected to the grid avoid the cost (and potential ugliness) of extending and connecting a line to a customer's site.

137 Distributed resources can improve utility system reliability by powering vital protective functions of the grid even if its own power supply fails.

138 The modularity of many distributed resources enables them to scale down advantageously to small loads that would be uneconomic to serve with grid power because its fixed connection costs could not be amortized from electricity revenues.

139 Many distributed resources, notably photovoltaics, have costs that scale far more closely to their loads than do the costs of distribution systems.

140 Distributed generators provide electric energy that would otherwise have to be generated by a centralized plant, backed up by its spinning reserve, and delivered through grid losses to the same location.

141 Distributed resources available on peak can reduce the need for the costlier to-keep-warm centralized units.

142 Distributed resources very slightly reduce spinning reserves' operational cost.

143 Distributed resources can reduce power stations' startup cycles, thus improving their efficiency, lifetime, and reliability.

144 Inverter-driven distributed resources can provide extremely fast ramping to follow sudden increases or decreases in load, improving system stability and component lifetimes.

145 By combining fast ramping with flexible location, often in the distribution system, distributed resources may provide special benefits in correcting transients locally before they propagate upstream to affect more widespread transmission and generating resources.

146 Distributed resources allow for net metering, which in general is economically beneficial to the distribution utility (albeit at the expense of the incumbent generator).

147 Distributed resources may reduce utilities' avoided marginal cost and hence enable them to pay lower buyback prices to Qualifying Facilities.

148 Distributed resources' ability to provide power of the desired level of quality and reliability to particular customers—rather than just a homogeneous commodity via the grid—permits providers to match their offers with customers' diverse needs and to be paid for that close fit.

149 Distributed resources can avoid harmonic distortion in the locations where it is both more prevalent (*e.g.*, at the end of long rural feeders) and more costly to correct.

150 Certain distributed resources can actively cancel harmonic distortion in real time, at or near the customer level.

151 Whether provided passively or actively, reduced harmonics means lower grid losses, equipment heating (which reduces life and reliability), interference with end-user and grid-control equipment, and cost of special harmonic-control equipment.

152 Appropriately designed distributed inverters can actively cancel or mitigate transients in real time at or near the customer level, improving grid stability.

153 Many distributed resources are renewable, and many customers are willing to pay a premium for electricity produced from a non-polluting generator.

154 Distributed resources allow for local control of generation, providing both economic-development and political benefits.

155 Certain distributed nonelectric supply-side resources such as daylighting and passive ventilation can valuably improve non-energy attributes (such as thermal, visual, and acoustic comfort), hence human and market performance.

156 Bundling distributed supply- with demand-side resources increases many of distributed generation's distributed benefits per kW, *e.g.*, by improving match to loadshape, contribution to system reliability, or flexibility of dispatching real and reactive power.

157 Bundling distributed supply- with demand-side resources means less supply, improving the marketability of both by providing more benefits (such as security of supply) per unit of cost.

158 Bundling distributed supply- with demand-side resources increases the provider's profit or price flexibility by melding lower supply-side with higher demand-side margins.

159 Certain distributed resources can valuably burn local fuels that would otherwise be discarded, often at a financial and environmental cost.

160 Distributed resources provide a useful amount and temperature of waste heat conveniently close to the end-use.

161 Photovoltaic (or solar-thermal) panels on a building's roof can reduce the air conditioning load by shading the roof—thus avoiding air-conditioner and air-handling capacity, electricity, and the capacity to generate and deliver it, while extending roof life.

162 Some distributed resources like microturbines produce carbon dioxide, which can be used as an input to greenhouses or aquaculture farms.

163 Some types of distributed resources like photovoltaic tiles integrated into a roof can displace elements of the building's structure and hence of its construction cost.

164 Distributed resources make possible homes and other buildings with no infrastructure in the ground—no pipes or wires coming out—thus saving costs for society and possibly for the developer.

165 Because it lacks electricity, undeveloped land may be discounted in market value by more than the cost of installing distributed renewable generation—making that power source better than free.

166 Since certain distributed resources don't pollute and are often silent and inconspicuous, they usually don't reduce, and may enhance, the value of surrounding land—contrary to the effects of central power plants.

167 Some distributed resources can be installed on parcels of land that are too small, steep, rocky, odd-shaped, or constrained to be valuable for real-estate development.

168 Some distributed resources can be double-decked over other uses, reducing or eliminating net land costs. (Double-decking over utility substations, etc., can also yield valuable shading benefits that reduce losses (# 168) and extend equipment life.)

169 The shading achieved by double-decking PVs above parked cars or livestock can yield numerous private and public side-benefits.

170 Distributed resources may reduce society's subsidy payments compared with centralized resources.

171 Distributed resources can significantly—and when deployed on a large scale can comprehensively and profoundly—improve the resilience of electricity supply, thus reducing many kinds of social costs, risks, and anxieties, including military costs and vulnerabilities.

172 Technologies perceived as benign in their local impacts make siting approvals more likely, reducing the risk of project failure and lost investment and hence reducing the risk premium demanded by investors.

173 Technologies perceived as benign or de minimis in their local impacts can often also receive siting approvals faster, or can even be exempted from approvals processes, further shortening construction time and hence reducing financial cost and risk.

174 Technologies perceived as benign in their local impacts have wide flexibility in siting, making it possible to shop for lower-cost sites.

175 Technologies perceived as benign in their local impacts have wide flexibility in siting, making it easier to locate them in the positions that will maximize system benefits.

176 Siting flexibility is further increased where the technology, due to its small scale, cogeneration potential, and perhaps nonthermal nature, requires little or no heat sink.

177 Distributed resources' local siting and implementation tend to increase their local economic multiplier and thereby further enhance local acceptance.

178 Distributed resources can often be locally made, creating a concentration of new skills, industrial capabilities, and potential to exploit markets elsewhere.

179 Most well-designed distributed resources reduce acoustic and aesthetic impacts.

180 Distributed resources can reduce irreversible resource commitments and their inflexibility.

181 Distributed resources facilitate local stakeholder engagements and increase the community's sense of accountability, reducing potential conflict.

182 Distributed resources generally reduce and simplify public health and safety impacts, especially of the more opaque and lasting kinds.

183 Distributed resources are less liable to the regulatory "ratcheting" feedback that tends to raise unit costs as more plants are built and as they stimulate more public unease.

184 Distributed resources are fairer, and seen to be fairer, than centralized resources because their costs and benefits tend to go to the same people at the same time.

185 Distributed resources have less demanding institutional requirements, and tend to offer the political transparency and attractiveness of the vernacular.

186 Distributed resources lend themselves to local decisions, enhancing public comprehension and legitimacy.

187 Distributed resources are more likely than centralized ones to respect and fit community and jurisdictional boundaries, simplifying communications and decision-making.

188 Distributed resources better fit the scale of communities' needs and ability to address them.

189 Distributed resources foster institutional structure that is more weblike, learns faster, and is more adaptive, making the inevitable mistakes less likely, consequential, and lasting.

190 Distributed resources' smaller, more agile, less bureaucratized institutional framework is more permeable and friendly to information flows inward and outward, further speeding learning.

191 Distributed resources' low cost and short lead time for experimental improvement encourages and rewards more of it and hence accelerates it.

192 Distributed resources' size and technology (frequently well correlated) generally merit and enjoy a favorable public image that developers, in turn, are generally both eager and able to uphold and enhance, aligning their goals with the public's.

193 With some notable exceptions such as dirty engine generators, distributed resources tend to reduce total air emissions per unit of energy services delivered.

194 Since distributed resources' air emissions are directly experienced by the neighbors with the greatest influence on local acceptance and siting, political feedback is short and quick, yielding strong pressure for clean operations and continuous improvement.

195 Due to scale, technology, and local accountability informed by direct perception, the rules governing distributed resources are less likely to be distorted by special-interest lobbying than those governing centralized resources.

196 Distributed utilities tend to require less, and often require no, land for fuel extraction, processing, and transportation.

197 Distributed resources' land-use tends to be temporary rather than permanent.

198 Distributed resources tend to reduce harm to fish and wildlife by inherently lower impacts and more confined range of effects (so that organisms can more easily avoid or escape them).

199 Some distributed resources reduce and others altogether avoid harmful discharges of heat to the environment.

200 Some hydroelectric resources may be less harmful to fish at small than at large scale.

201 The greater operational flexibility of some distributed resources, and their ability to serve multiple roles or users, may create new opportunities for power exchange benefiting anadromous fish.

202 Well-designed distributed resources are often less materials- and energy-intensive than their centralized counterparts, comparing whole systems for equal delivered production.

203 Distributed resources' often lower materials and energy intensity reduces their indirect or embodied pollution from materials production and manufacturing.

204 Many distributed resources' reduced materials intensity reduces their indirect consumption of depletable mineral resources.

205 The small scale, standardization, and simplicity of most distributed resources simplifies their repair and may improve the likelihood of their remanufacture or recycling, further conserving materials.

206 Many distributed resources withdraw and consume little or no water.

207 Many distributed resources offer psychological or social benefits of almost infinite variety to users whose unique prerogative it is to value them however they choose.